(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 876 051 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.09.2021 Bulletin 2021/36

(21) Application number: **20382159.0**

(22) Date of filing: **05.03.2020**

(51) Int Cl.:
G05B 19/414 *(2006.01)* ***G05B 19/418*** *(2006.01)*
B41J 29/393 *(2006.01)* ***H04L 12/40*** *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **UNITED BARCODE SYSTEMS, S.L.**
08340 Vilassar de Mar (ES)

(72) Inventor: **BONET LOZANO, Antoni Maria**
08340 VILASSAR DE MAR (ES)

(74) Representative: **Ponti & Partners, S.L.P**
C. de Consell de Cent 322
08007 Barcelona (ES)

(54) **A PRINTING SYSTEM AND A FIELD DEVICE CONTROL UNIT FOR A PRINTING SYSTEM**

(57) The present invention relates to a printing system, comprising:
- a printing head (H),
- field devices (D1-D5); and
- a distributed control system comprising:
- a printer control unit (PE) connected to the printing head (H) to control the operation thereof;
- field device control units (C) connected to the field devices (D1-D5); and
- a fieldbus (B) interconnecting the printer control unit (PE) and field device control units (C).

The fieldbus (B) provides a real-time communication, and in the field device control units (C) are adapted to be operatively connected, in an interchangeable manner, to each of a plurality of field devices (D1-D5), each configured and arranged to perform a distinct task of the printing process.

The present invention also relates to a field device control unit adapted to operate for the printing system of the invention.

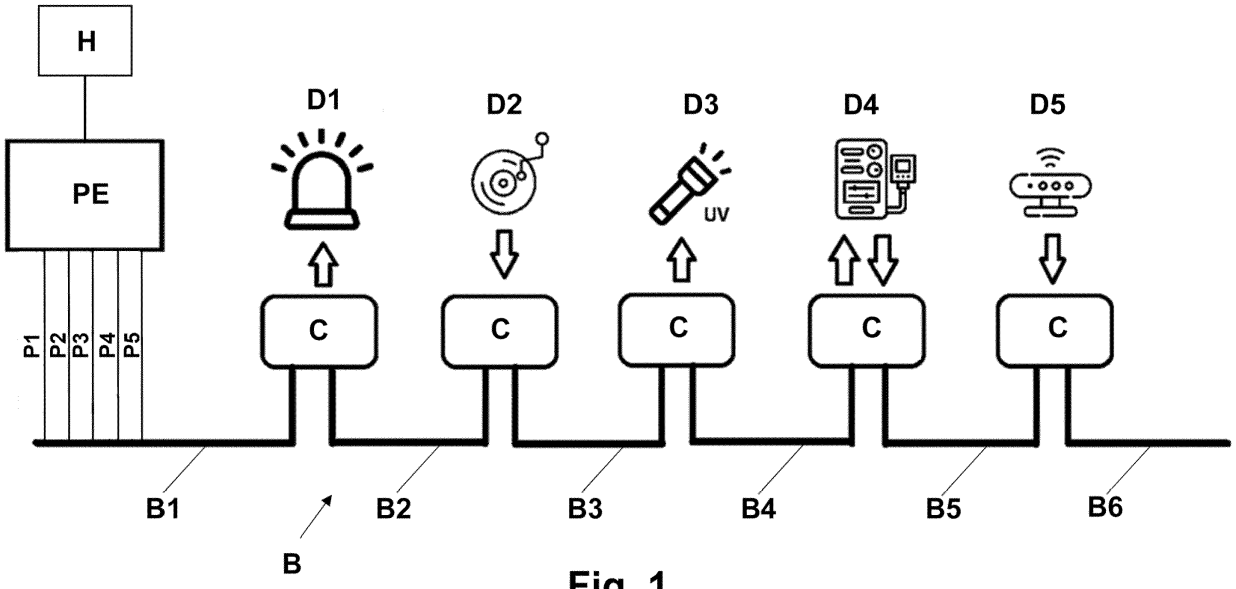

Fig. 1

EP 3 876 051 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates, in a first aspect, to a printing system comprising a distributed control system, and more particularly to a printing system allowing real-time communication between their components and a high adaptability to different types of field devices.

[0002] In a second aspect, the present invention relates to a field device control unit adapted to operate for the printing system of the first aspect of the invention.

BACKGROUND OF THE INVENTION

[0003] A printing system consists of a control unit or print engine that controls a printing head of one of several existing technologies, such as inkjet, thermal transfer, laser, etc., generally with a high speed connection with a PC or Central Processing Unit that generates the information to be printed.

[0004] Depending on the technology, it can also incorporate a UV solidification or curing system, an ink supply hydraulic system, cameras or detectors for printing validation, light or acoustic indicators of the system status, control input lines, lines of control output, object speed detectors, etc.

[0005] If the printing system is a compact element that incorporates all of the above mentioned components, the solution is quite simple. The interconnections are fixed and many times several elements or all of them coexist on the same electronic board. Likewise, the power supply is also fixed and known.

[0006] But in an industrial environment, things get complicated. The size of the components of the printing system is so large that a compact solution is not possible. It may also be necessary for the various components to be distributed and at some distance from each other, complicating their interconnection and, sometimes, forcing them not to be separated from one another or to duplicate certain functions.

[0007] There are different solutions to interconnect those components, even over great distances. These are the so-called fieldbuses: CAN, Modbus, Profibus, Ethernet Powerlink, etc. but the connections provided by those fieldbuses only allow data to be exchanged asynchronously, that is, a certain time passes between the origin of the request and the response of the system to it. For many control functions this is sufficient, but others need immediate response times, or synchronous communication. Some of these functions can be analog variables, reference clocks or events that launch processes synchronously.

[0008] Also for these problems there are solutions such as 0-20 mA or 4-20 mA analog current loops, IEEE1588, but all of them, including the known fieldbuses, require dedicated, expensive and different special hardware for each of them. Some components may need to be powered by the bus itself, sometimes with different voltage values.

[0009] The installation of additional components can be complex and require special configurations.

[0010] Printing systems comprising the features of the preamble of claim 1 are known in the art, i.e.:

- a printing head configured and arranged to print on a substrate as part of a printing process,
- at least one field device configured and arranged to perform a further task of said printing process; and
- a distributed control system comprising:
  - a printer control unit with computing capabilities, that is operatively connected to said printing head to control the operation thereof;
  - at least one field device control unit with computing capabilities, that is operatively connected to said at least one field device to control at least part of the operation thereof; and
  - a fieldbus interconnecting at least said printer control unit and said at least one field device control unit.

[0011] However, those known printing systems have the above mentioned drawbacks associated to the inclusion of prior art fieldbuses and/or of the need of different special dedicated hardware.

[0012] It is, therefore, necessary to provide an alternative to the state of the art which covers the gaps found therein, by providing a printing system which does not have the above mentioned drawbacks of the proposals of the prior art, and which particularly allows the implementation of any of the above mentioned functions without needing different special dedicated hardware.

SUMMARY OF THE INVENTION

[0013] To that end, the present invention relates, in a first aspect, to a printing system, comprising:

- a printing head configured and arranged to print on a substrate as part of a printing process,
- at least one field device configured and arranged to perform a further task of said printing process; and
- a distributed control system comprising:
  - a printer control unit with computing capabilities, that is operatively connected to said printing head to control the operation thereof;
  - at least one field device control unit with computing capabilities, that is operatively connected to said at least one field device to control at least part of the operation thereof; and
  - a fieldbus interconnecting at least said printer control unit and said at least one field device control unit.

[0014] In the printing system of the first aspect of then present invention, in a characteristic manner, the fieldbus provides a real-time communication between the printer control unit and the at least one field device control unit, and the at least one field device control unit is adapted to be operatively connected, in an interchangeable manner, to each of a plurality of field devices, each configured and arranged to perform a distinct task of said printing process, said plurality of field devices including the above mentioned at least one field device.

[0015] Depending on the embodiment, the plurality of field devices comprises at least two of the following field devices: a UV solidification or curing device, an ink supply hydraulic device, a camera or detector for printing validation and/or for detecting the presence of a predetermined to-be-printed area of the substrate, a light or acoustic indicator of the system status, a control input line device, a control output line device, a moving object speed and/or direction detector, a machine readable code reader device, a conveyor start/stop switch status device, and a PLC.

[0016] Generally, the printing system of the first aspect of the present invention comprises two or more field devices of the above mentioned at least one field device and two or more respective field device control units of the above mentioned at least one field device control unit.

[0017] The fieldbus interconnects the printer control unit and the at least one field device control unit or two or more field device control units, according to a ring topology, for an embodiment, or according to a bus topology, for another embodiment.

[0018] For a preferred embodiment, the fieldbus comprises the following wire pairs:

- a first pair, for power supplying at least the at least one field device control unit or the two or more field device control units;
- a second pair, for bidirectional data serial communication between the different components operatively connected to the fieldbus, including the printer control unit and the at least one field device control unit or the two or more field device control units;
- a third pair, for providing a synchronism signal to the different components operatively connected to the fieldbus, including the printer control unit and the at least one field device control unit or the two or more field device control units, to synchronize the operations thereof; and
- a fourth pair, for providing said real-time communication by means of a real-time bidirectional transmission of electrical signals representative of real-time events associated to any of the printer control unit, the at least one field device control unit or the two or more field device control units.

[0019] According to an embodiment, the fieldbus further comprises a fifth wire pair, for bidirectional data communication with further field devices, or with a further printer control unit connected to the same fieldbus or to a further fieldbus to synchronize the operation of the printing heads and field devices operatively connected to the fieldbus or fieldbuses, for carrying out a common printing process or individual but synchronized printing processes.

[0020] The fourth pair of the field bus is preferably configured and arranged for the multiplexed transmission of several of the above mentioned electrical signals corresponding to different real-time events.

[0021] According to an embodiment, the printer control unit is configured and arranged to identify, from information sent and received through the fieldbus second pair to/from any of the at least one field device control unit or of the two or more field device control units, a specific field device operatively connected thereto.

[0022] For an implementation of said embodiment, the printer control unit is configured and arranged to transmit, through the fieldbus second pair, program instructions data to any of the at least one field device control unit or of the two or more field device control units, to program or re-program the same to adapt its operation to the identified field device operatively connected thereto.

[0023] For another implementation of the above mentioned embodiment, the printer control unit is configured and arranged to transmit, through the fieldbus second pair, different types of data to any of the at least one field device control unit or of the two or more field device control units, to at least one of:

- assigning an identifier to the same,
- configuring the same for operating, for the real-time bidirectional transmission through the fieldbus fourth pair or for the provision of said synchronism signal through the third pair, and the associated synchronized components operations, as a master or as a slave, depending on which kind of field device is the identified field device, and
- power supplying, through the fieldbus first pair, a field device control unit connected downstream to the fieldbus, from the power supply received from the printer control unit, also from the fieldbus first pair.

[0024] For some embodiments, a further computer entity is connected to the printer control unit to exchange data therewith and provide the same with printing jobs to be processed by the printing system to carry out a printing process. Preferably, that computer entity is provided with a HMI (Human-Machine Interface) to allow an operator to interact with the same.

[0025] For an embodiment, the substrate is a moving object, and the printer control unit is configured and arranged to configure as a master the field device control unit to which the identified field device is operatively connected and as slaves the rest of components operatively connected to the fieldbus, for the provision of the synchronism signal through the fieldbus third pair and associated synchronized components operations, when the

identified field device is a detector arranged for detecting the moving object speed and direction, such as an encoder.

[0026] According to another embodiment, the printer control unit is configured and arranged to configure as a master the field device control unit to which the identified field device is operatively connected, for the real-time bidirectional transmission through the fieldbus fourth pair, when the identified field device is a detector, such as a photocell, arranged for printing validation and/or for detecting the presence of a predetermined to-be-printed area of the substrate.

[0027] The printing system of the first aspect of the present invention provides, therefore, a distributed control system based on a multiple bus, or several buses in one, with a cable with four, or preferably five, wire pairs, and programmable and configurable interconnection bases (field device control units), to which the different accessories or satellites (field devices), of the system are connected.

[0028] The interconnection base serves as a repeater for the fieldbus, as an identifier of the field device(s) connected to said base, as a power supply for the field device(s) that requires it, as a data collector for the fieldbus and for control and execution of orders that come through the fieldbus. Each base is preferably reprogrammable in the field through the same fieldbus or locally from the base itself.

[0029] A second aspect of the present invention relates to a field device control unit for a printing system, wherein the field device control unit is defined as the at least one field device control unit of the printing system of the first aspect of the present invention.

[0030] For an embodiment, the field device control unit of the second aspect of the present invention comprises:

- first and second bus ports configured and arranged for operatively connecting the field device control unit to the fieldbus, the first bus port to a fieldbus segment coming from the printer control unit or from an upstream field device control unit and the second bus port to a fieldbus segment going to a downstream field device control unit;
- field device ports configured and arranged for operatively connecting the field device control unit, in an interchangeable manner, to each of the above mentioned plurality of field devices; and
- processing means operatively connected to the first and second bus ports and the field device ports, and programmed to process data coming therefrom in a manner which follows program instructions and at least depends on the kind of field device operatively connected to the field device ports.

[0031] For an implementation of that embodiment, the processing means are adapted:

- to identify the field device operatively connected to the field device ports, automatically or with the collaboration of the printer control unit, and
- to re-program its program instructions to adapt its operation to the identified field device operatively connected thereto, the processing means being adapted to carry out said re-programing automatically or with the collaboration of the printer control unit or of another computing entity or interface connected to the field device control unit.

[0032] In a another aspect, the present invention relates to a method adapted to perform a printing process by carrying out the operation steps of the printing system of the present invention, for any of its embodiments.

BRIEF DESCRIPTION OF THE FIGURES

[0033] In the following some preferred embodiments of the invention will be described with reference to the enclosed Figures. They are provided only for illustration purposes without however limiting the scope of the invention.

Figure 1 schematically shows the printing system of the first aspect of the present invention for an embodiment for which the different components thereof are interconnected to the fieldbus according to a bus topology.

Figure 2 schematically shows the field device control unit of the second aspect of the present invention, for an embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] For the embodiment illustrated in Figure 1, the printing system of the first aspect of the present invention comprises:

- a printing head H configured and arranged to print on a substrate (not shown) as part of a printing process;
- five field devices D1-D5 configured and arranged to perform a further task of the printing process, particularly a light indicator D1, an encoder D2, a UV lamp D3, a PLC D4, and a detector D5; and
- a distributed control system comprising:
  - a printer control unit PE with computing capabilities, that is operatively connected to the printing head H to control the operation thereof;
  - five field device control units C with computing capabilities, each operatively connected to a respective field device D1-D5 to control at least part of the operation thereof; and
  - a fieldbus B interconnecting the printer control unit PE and field device control units C, in this case according to a bus topology.

[0035] The fieldbus B provides a real-time communication between the printer control unit PE and the field device control units C, each of which is adapted to be operatively connected, in an interchangeable manner, to each of the field devices D1-D5.

[0036] Although five specific field devices D1-D5 are depicted in Figure 1, less of more of those or of other kind of field devices can be included in the printing system for other embodiments, depending on the specific printing process to be implemented by the system.

[0037] For the illustrated embodiment, the fieldbus B comprises the following wire pairs:

- a first pair P1, for power supplying the field device control units C, with power obtained from the printer control unit PE, preferably with current limitation and a sufficient magnitude to power both the field device control units C and the field devices D1-D5 connected to them (provided they are low power consumption devices);
- a second pair P2, or data bus, for bidirectional data serial communication between the different components operatively connected to the fieldbus B, i.e. the printer control unit PE and the field device control units C. This pair is preferably a 485 differential pair to ensure robustness in the industrial environment, with sufficient length and high transmission speed. Through this data bus, the field device control unit C will be programmed (when not programmed locally from the field device control unit C itself), the field device control unit C will be identified and orders, configurations and data will be exchanged between the printer control unit PE and the field device control units C of the system;
- a third pair P3, for providing a synchronism/clock signal to the different components operatively connected to the fieldbus B, i.e. the printer control unit PE and the field device control units C, to synchronize the operations thereof. The synchronism/clock signal can come from the printer control unit PE or from a filed device control unit C or field device D1-D5, such as an encoder. This pair is preferably a 485 differential pair;
- a fourth pair P4, for providing the above mentioned real-time communication by means of a real-time bidirectional transmission of several time-multiplexed electrical signals corresponding to different real-time events associated to the printer control unit PE and/or the field device control units C. If this multiplexing is done, for example, at 12 Mbps, the printing system can capture an event with a delay of 0.83 μs, which in practice can be considered real time. This pair is preferably a 485 differential pair; and
- a fifth wire pair P5, or auxiliary data bus, for bidirectional data communication with further field devices, such as additional components (WiFi mode, cameras, etc.), or with a further printer control unit PE connected to the same fieldbus B or to a further fieldbus (not shown) to synchronize the operation of the printing heads and field devices operatively connected to the fieldbus B or to different fieldbuses, for carrying out a common synchronized printing process or individual but synchronized printing processes, synchronizing different fieldbuses or generate sophisticated printing blocks. This pair is preferably a 485 differential pair.

[0038] The field device control unit C depicted in Figure 2 corresponds to both the one of the second aspect of the present invention and also the one of the printing system of the first aspect of the present invention, and is described with more detail below.

[0039] As shown in Figure 2, the field device control unit C comprises first Pb1 and second Pb2 bus ports configured and arranged for operatively connecting the field device control unit C to the fieldbus B, the first bus port Pb1 to a fieldbus segment B1-B5 coming from the printer control unit PE (for the unit C connected to D1) or from an upstream field device control unit C (for the rest of field device control units C) and the second bus port Pb2 to a fieldbus segment B2-B6 going to a downstream field device control unit C.

[0040] The field device control unit C further comprises:

- field device ports Pd1, Pd2, Pd3 configured and arranged for operatively connecting the field device control unit C, in an interchangeable manner, to each of the plurality of field devices D1-D5; and
- processing means CPU operatively connected to the first Pb1 and second Pb2 bus ports and to the field device ports Pd1, Pd2, Pd3, and programmed to process data coming therefrom in a manner which follows program instructions and at least depends on the kind of field device D1-D5 operatively connected to the field device ports Pd1, Pd2, Pd3.

[0041] For an embodiment, the processing means CPU are adapted:

- to identify the field device D1-D5 operatively connected to the field device ports D1-D5, automatically or with the collaboration of the printer control unit PE, and
- to re-program its program instructions to adapt its operation to the identified field device D1-D5 operatively connected thereto, the processing means CPU being adapted to carry out said re-programing automatically or with the collaboration of the printer control unit PE or of another computing entity or interface connected to the field device control unit C.

[0042] Preferably, ports Pb1 and Pb2 are implemented by a type of connector which is different to the type of connector(s) implementing ports Pd1, Pd2, Pd3, in order to avoid connection errors, i.e. to avoid connecting a field

device D1-D5 to ports Pb1 and Pb2 or a field bus segment B1-B6 to ports Pd1, Pd2, Pd3.

[0043] All connectors are preferably suitable for the industrial environment, with secure connection and symmetrical, that is, it does not matter how they are connected between field device control units C and with the printer control unit PE.

[0044] For the illustrated embodiment (as indicated by the depicted arrow lines), port Pd1 is an input port, port Pd2 is an output port, and ports Pd3, Pb1, and Pb2 are input/output ports.

[0045] Generally, the processing means CPU are implemented by means of a microprocessor, and associated circuitry and electronic components, arranged on a printed circuit board.

[0046] Although not shown, in addition to the processing means CPU, for some embodiments, the field device control unit C further comprises electric and/or electronic circuitry in charge of carrying out complementary functions, such as signal conditioning, arranged whether on the above mentioned printed circuit board or in another one.

[0047] The illustrated field device control unit C comprises an enclosure E housing within the different components thereof, and through openings for accessing each of its ports, i.e. Pb1, Pb2, Pd1, Pd2, Pd3, so that they can be connected to the fieldbus B and one field device D1-D5.

[0048] Depending on how it is programmed, the field device control unit C can act, with respect to the information, data or signals flowing through the fieldbus B, as a bypass, repeater, passive, or active unit for each, for all or for any of the pairs that make up the fieldbus B. In this manner, different master/slave type connections can be created, independently for each of the second, third, fourth and fifth pair, i.e. for any of those pairs the printer control unit PE or any of the field device control units C can act as master while the rest of components connected to the fieldbus B act as slaves, and for another pair another of those components can act as a master and the rest as slaves. Also, the field device control unit C can cut or allow the passage of power supply to the rest of components connected to the fieldbus B.

[0049] The input-output part of the field device control unit C, i.e. that constituted by ports Pd1, Pd2 and Pd3, is configured to connect any of the different field devices already mentioned herein, i.e. UV lamp, detectors, encoder, light or acoustic indicators/beacons, PLC, cameras, etc.

[0050] This field device control unit C can be programmed in-factory, it can be reconfigured in the field and can even automatically identify the field device connected to it.

[0051] The mode of operation is simple, as explained below:

When starting the printing system, the printer control unit PE acts as a master and power supplies the first connected field device control unit C, recognizes and identifies the field device connected thereto, configures the field device control unit C and instructs it to open the power supply (cut off at the beginning) to the next field device control unit C, repeating the process until there are no more elements in the chain, i.e. no more device control units C connected to the fieldbus B. Once all the field device control units C are configured, the master-slave roles are reassigned according to the programmed configuration. If a new field device is added, it will be recognized and the field device control unit C connected thereto configured as the previous ones, being immediately integrated into the printing system.

[0052] The incorporation of a new field device not foreseen in the implemented printing scheme will require only a small update of the recognition and configuration software included in the printing system, and follow the same procedure indicated for the rest of the previous field devices D1-D5 and associated field device control units C.

[0053] Therefore, the printing system is expandable without limitation, constituting a kind of plug-and-play system, where any filed device can be connected to any field device control unit and be automatically recognized and identified and thus integrated in the printing system.

[0054] The printing process implemented by the printing system of the present inventions is described with more detail below, for a specific embodiment.

[0055] For that specific embodiment, the printing system has a minimum configuration with a printing head H, its associated printer control unit PE, and connected to the fieldbus B, a signalling beacon D1, a photocell detector D5 and an encoder D2 as a speed detector element.

[0056] The components are interconnected to the fieldbus B as follows (the order may vary due to the needs of the production line): the printer control unit PE is connected to the signalling beacon D1, which is connected to the encoder D2 and the latter is connected to the photocell detector D5. I.e. a printing scheme as that shown in Figure 1 but without field devices D3 and D4.

[0057] The printer control unit PE power supplies the beacon D1, and the processing means CPU of the field device control unit C connected thereto communicates informing that the field device D1 is a signalling beacon. Then, the printer control unit PE assigns, to that field device D1 and field device control unit C, an identifier on the fieldbus B, recognizes it as a slave element and instructs it to allow the pass of power supply to the next component. From now on, the beacon D1 and associated field device control unit C will only respond when the communications package identifier matches the one assigned to it.

[0058] The power supply reaches the encoder D2 that still has no identifier assigned, so the printer control unit PE proceeds to interrogate the field device control unit C connected to the encoder D2 in order to recognize it. The printer control unit PE detects that the field device is an encoder D2, assigns it an identifier and in the third pair P3 the field device control unit C connected thereto

is programmed as a master, becoming the rest of the components and even the same printer control unit PE slaves in that third pair P3. The field device control unit C connected to the encoder D2 is then instructed to enable the power supply to reach the next component and the process is repeated with the photocell detector D5.

[0059] Then, the printer control unit PE recognizes that the field device D5 is a photocell detector, configures the field device control unit C connected thereto as a master in the fourth pair P4, assigns the same a corresponding identifier in the fieldbus B and instructs the same to enable the power supply to reach a possible next component in the fieldbus B.

[0060] There are no more components connected to the fieldbus B, therefore, those already present have their function assigned and are perfectly identified.

[0061] After a while, in case a UV curing lamp had to be incorporated into the printing system, a further field device control unit C connected to that UV curing lamp would be connected to the fieldbus B, specifically to the last identified component, i.e. to the field device control unit C connected to the photocell detector D5, and the previous processes would be repeated, identifying and configuring the new component quickly, easily and without errors, and without the need to change the order or position of the components already existing in the printing system.

[0062] Alternatively, the new field device, such as that UV curing lamp, could be connected to a field device control unit C already connected to the fieldbus B, even if that was already connected to a field device, substituting the same with the new one, and/or to a field device control unit C to be connected at any point of the fieldbus B, no matter its position, i.e. not necessarily after the last identified component.

[0063] In the case that there are two or more printing heads H on the same printing line in order to print in colours, or increase the width of the printing area, then there will be several printer control units PEs that will have to be synchronized in some way. The auxiliary pair, i.e. the fifth pair P5, will be responsible for intercommunicating the different PEs and reprogramming their synchronous pairs, i.e. third pairs P3, so that they all share the same synchronization signal, and even the same detectors for the real-time pairs, i.e. fourth pairs P4.

Real case:

[0064] For implementing a printing process, according to a real case implemented by the present inventors, a printer control unit is included that uses a rotary position encoder that generates a synchronization signal of up to 2 MHz, a signal that indicates the direction of rotation of the encoder, three or more signals that come from the printer control unit to generate warnings, alarms or status indicator light signals, two "real time" input signals to the printer control unit, that is, which must generate immediate response, two or more status signals from external elements, such as PLC, conveyor start-stop switch, etc., control signals of curing lamps, and barcode readers.

[0065] This mixture of signals of different speeds and that require varied response times cannot be integrated into a standard industrial bus due to its different characteristics.

[0066] The fieldbus B is capable of transporting all of them between the different components of the printing system of the present invention without using a hose of 25 wires or more. For the here described real case:

- There is a single 12 V supply from which the power supplies necessary for the rest of components can be extracted, through first pair P1.
- There is a differential pair, or second pair P2, providing a serial communication to a minimum of 115 Kbps that serves to:
  - Identify components connected to the fieldbus B;
  - Program those components;
  - Collect input status signals to the printer control unit;
  - Transport output signals to control alarms or light indicators, or orders to PLCs
  - Transmit data from smart devices such as barcode readers, etc.
- There is a differential pair, or third pair P3, that carries the speed synchronization signal obtained from a rotary speed encoder.
- There is a differential pair, or fourth pair P4, that transmits a periodic signal at high speed where the "real time" signals are introduced multiplexed. The "real time" consideration is given by the repetition rate of the data transmitted by this pair. If data is sent at 10 Mbps one can have a real value of the signal in question after 1 μs, which, for a photocell signal, for example, that marks the beginning of a printing operation, it would mean a response delay of 2 microns for a system that moves at a speed of 120 m/minute. So up to 8 signals can be sent at once. If an industrial bus at a speed of 115Kbps was used with very fast microprocessors and low latency in the response one could have a data as soon as 1 millisecond after the event, which at the speed indicated above would provide a response offset 2 mm after the occurrence of the detection. If the system could not respond to the event in 5 milliseconds the offset would be 10 mm. This is surely not feasible, that's the reason of the need of what has been called "real time" in this type of signals.

[0067] The connection of new devices is done in a controlled and cascading manner, avoiding that, as could happen in the case of connecting two speed encoders in the fieldbus B, the signal of one could distort that of the other. What will happen in this case is that this second

encoder will not be power supplied avoiding a malfunction of the system or, even if the new encoder is power supplied, its signal will not be allowed to be incorporated into the fieldbus B to the corresponding pair.

[0068] A person skilled in the art could introduce changes and modifications in the embodiments described without departing from the scope of the invention as it is defined in the attached claims.

Claims

1. A printing system, comprising:

- a printing head (H) configured and arranged to print on a substrate as part of a printing process,
- at least one field device (D1-D5) configured and arranged to perform a further task of said printing process; and
- a distributed control system comprising:

  - a printer control unit (PE) with computing capabilities, that is operatively connected to said printing head (H) to control the operation thereof;
  - at least one field device control unit (C) with computing capabilities, that is operatively connected to said at least one field device (D1-D5) to control at least part of the operation thereof; and
  - a fieldbus (B) interconnecting at least said printer control unit (PE) and said at least one field device control unit (C);

characterized in that said fieldbus (B) provides a real-time communication between said printer control unit (PE) and said at least one field device control unit (C), and **in that** the at least one field device control unit (C) is adapted to be operatively connected, in an interchangeable manner, to each of a plurality of field devices (D1-D5), each configured and arranged to perform a distinct task of said printing process, said plurality of field devices including said at least one field device (D1-D5).

2. The printing system according to claim 1, wherein said plurality of field devices (D1-D5) comprise at least two of the following field devices: a UV solidification or curing device, an ink supply hydraulic device, a camera or detector for printing validation and/or for detecting the presence of a predetermined to-be-printed area of the substrate, a light or acoustic indicator of the system status, a control input line device, a control output line device, a moving object speed and/or direction detector, a machine readable code reader device, a conveyor start/stop switch status device, and a PLC.

3. The printing system according to claim 1 or 2, comprising two or more field devices (D1-D5) of said at least one field device (D1-D5) and two or more respective field device control units (C) of said at least one field device control unit (C).

4. The printing system according to any of the previous claims, wherein the fieldbus (B) interconnects the printer control unit (PE) and the at least one field device control unit (C) or two or more field device control units (C), according to a ring topology or a bus topology.

5. The printing system according to any of the previous claims, wherein said fieldbus (B) comprises the following wire pairs:

- a first pair (P1), for power supplying at least the at least one field device control unit (C) or the two or more field device control units (C);
- a second pair (P2), for bidirectional data serial communication between the different components operatively connected to the fieldbus (B), including the printer control unit (PE) and the at least one field device control unit (C) or the two or more field device control units (C);
- a third pair (P3), for providing a synchronism signal to the different components operatively connected to the fieldbus (B), including the printer control unit (PE) and the at least one field device control unit (C) or the two or more field device control units (C), to synchronize the operations thereof; and
- a fourth pair (P4), for providing said real-time communication by means of a real-time bidirectional transmission of electrical signals representative of real-time events associated to any of the printer control unit (PE), the at least one field device control unit (C) or the two or more field device control units (C).

6. The printing system according to claim 5, wherein the fieldbus (B) further comprises a fifth wire pair (P5), for bidirectional data communication with further field devices, or with a further printer control unit (PE) connected to the same fieldbus (B) or to a further fieldbus to synchronize the operation of the printing heads and field devices operatively connected to the fieldbus (B) or fieldbuses, for carrying out a common printing process or individual but synchronized printing processes.

7. The printing system according to claim 5 or 6, wherein said fourth pair (P4) is configured and arranged for the multiplexed transmission of several of said electrical signals corresponding to different real-time events.

8. The printing system according to any of claims 5 to 7, wherein the printer control unit (PE) is configured and arranged to identify, from information sent and received through said second pair (P2) to/from any of the at least one field device control unit (C) or of the two or more field device control units (C), a specific field device (D1-D5) operatively connected thereto.

9. The printing system according to claim 8, wherein the printer control unit (PE) is configured and arranged to transmit, through said second pair (P2), program instructions data to any of the at least one field device control unit (C) or of the two or more field device control units (C), to program or re-program the same to adapt its operation to the identified field device (D1-D5) operatively connected thereto.

10. The printing system according to claim 8 or 9, wherein the printer control unit (PE) is configured and arranged to transmit, through said second pair (P2), different types of data to any of the at least one field device control unit (C) or of the two or more field device control units (C), to at least one of:

    - assigning an identifier to the same,
    - configuring the same for operating, for the real-time bidirectional transmission through the fourth pair (P4) or for the provision of said synchronism signal through the third pair (P3), and the associated synchronized components operations, as a master or as a slave, depending on which kind of field device is the identified field device (D1-D5), and
    - power supplying, through the first pair (P1), a field device control unit (C) connected downstream to the fieldbus (B), from the power supply received from the printer control unit (PE), also from the first pair (P1).

11. The printing system according to claim 10 when depending on claim 2, wherein said substrate is a moving object, and wherein the printer control unit (PE) is configured and arranged to configure as a master the field device control unit (C) to which the identified field device (D1-D5) is operatively connected and as slaves the rest of components operatively connected to the fieldbus (B), for the provision of the synchronism signal through the third pair (P3) and associated synchronized components operations, when the identified field device (D1-D5) is a detector arranged for detecting the moving object speed and direction.

12. The printing system according to claim 10 or 11 when depending on claim 2, wherein the printer control unit (PE) is configured and arranged to configure as a master the field device control unit (C) to which the identified field device is operatively connected, for the real-time bidirectional transmission through the fourth pair (P4), when the identified field device (D1-D5) is a detector arranged for printing validation and/or for detecting the presence of a predetermined to-be-printed area of the substrate.

13. A field device control unit for a printing system, **characterized in that** the field device control unit is defined as the at least one field device control unit (C) of the printing system according to any of the previous claims.

14. The field device control unit according to claim 13, comprising:

    - first (Pb1) and second (Pb2) bus ports configured and arranged for operatively connecting the field device control unit (C) to the fieldbus (B), said first bus port (Pb1) to a fieldbus segment (B1-B5) coming from the printer control unit (PE) or from an upstream field device control unit (C) and said second bus port (Pb2) to a fieldbus segment (B2-B6) going to a downstream field device control unit (C);
    - field device ports (Pd1, Pd2, Pd3) configured and arranged for operatively connecting the field device control unit (C), in an interchangeable manner, to each of said plurality of field devices (D1-D5); and
    - processing means (CPU) operatively connected to said first (Pb1) and second (Pb2) bus ports and said field device ports (Pd1, Pd2, Pd3), and programmed to process data coming therefrom in a manner which follows program instructions and at least depends on the kind of field device (D1-D5) operatively connected to the field device ports (Pd1, Pd2, Pd3).

15. The field device control unit according to claim 14, wherein said processing means (CPU) are adapted:

    - to identify the field device (D1-D5) operatively connected to the field device ports (D1-D5), automatically or with the collaboration of the printer control unit (PE), and
    - to re-program its program instructions to adapt its operation to the identified field device (D1-D5) operatively connected thereto, the processing means (CPU) being adapted to carry out said re-programing automatically or with the collaboration of the printer control unit (PE) or of another computing entity or interface connected to the field device control unit (C).

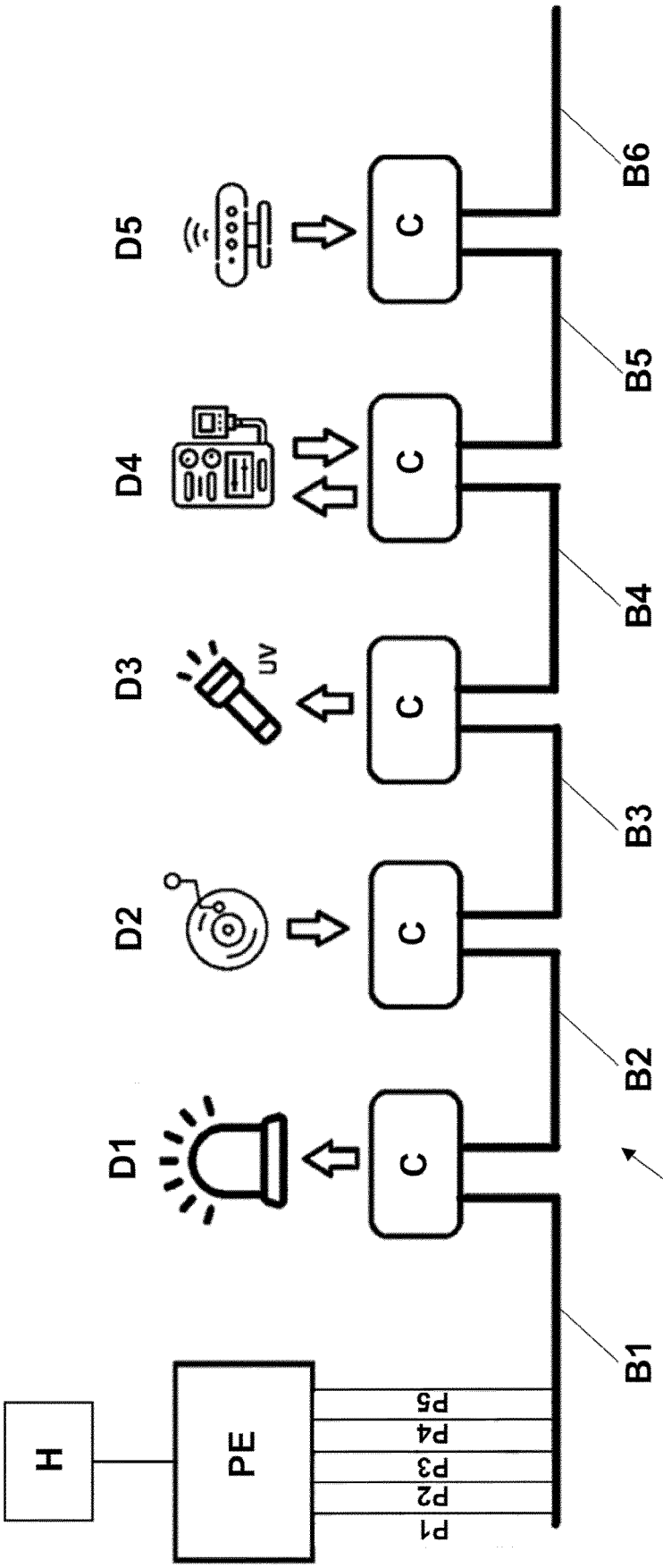

Fig. 1

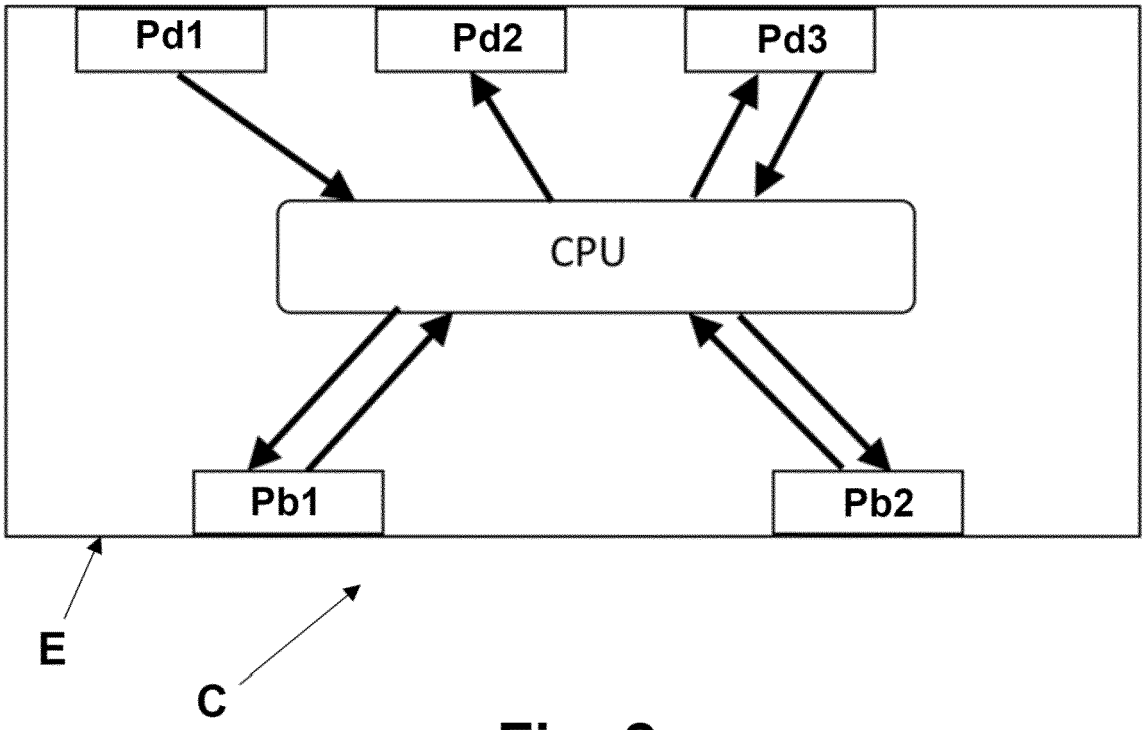

Fig. 2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 38 2159

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2019/352035 A1 (EGGL THOMAS [DE] ET AL) 21 November 2019 (2019-11-21) * paragraphs [0002], [0036], [0040], [0043], [0052], [0057], [0076]; figures 1-5 *	1-4, 13-15 5-12	INV. G05B19/414 G05B19/418 B41J29/393 H04L12/40
A	US 6 483 317 B1 (FLORO WILLIAM E [US] ET AL) 19 November 2002 (2002-11-19) * column 1, line 38 - column 1, line 53 *	1-15	
A	US 2006/267537 A1 (BAUMANN KEVIN L [US] ET AL) 30 November 2006 (2006-11-30) * figure 1 *	1-15	
A	US 6 532 508 B2 (PILZ GMBH & CO [DE]) 11 March 2003 (2003-03-11) * figure 1 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

G05B
B41J
H04L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	9 September 2020	Loi, Alberto

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 38 2159

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-09-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019352035 A1	21-11-2019	CN 109843731 A	04-06-2019
		DE 102016124266 A1	14-06-2018
		EP 3458367 A1	27-03-2019
		US 2019352035 A1	21-11-2019
		WO 2018108331 A1	21-06-2018
US 6483317 B1	19-11-2002	NONE	
US 2006267537 A1	30-11-2006	US 2006267537 A1	30-11-2006
		US 2009134829 A1	28-05-2009
US 6532508 B2	11-03-2003	AT 237150 T	15-04-2003
		AU 6428300 A	09-01-2001
		DE 19928517 A1	11-01-2001
		EP 1188096 A1	20-03-2002
		JP 4480311 B2	16-06-2010
		JP 2003502770 A	21-01-2003
		US 2002126620 A1	12-09-2002
		WO 0079353 A1	28-12-2000

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82